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Health effects on nearby residents of a wood treatment plant[☆], [☆☆]

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Abstract

Objectives: The aim of the study was to evaluate the health status of nearby residents of a wood treatment plant who had sustained prolonged low-level environmental exposure to wood processing waste chemicals. Methods: A population of 1269 exposed residents who were plaintiffs or potential plaintiffs in a lawsuit against the wood treatment plant were evaluated by questionnaire for a health history and symptoms. A representative sample of 214 exposed subjects was included in the analysis. One hundred thirty-nine controls were selected from 479 unexposed volunteers and matched to the exposed subjects as closely as possible by gender and age. Subjects and controls completed additional questionnaires and were evaluated by a physician for medical history and physical examination, blood and urine testing, neurophysiological and neuropsychological studies, and respiratory testing. Environmental sampling for wood processing waste chemicals was carried out on soil and drainage ditch sediment in the exposed neighborhood. Results: The exposed subjects had significantly more cancer, respiratory, skin, and neurological health problems than the controls. The subjective responses on questionnaires and by physician histories revealed that the residents had a significantly greater prevalence of mucous membrane irritation, and skin and neurological symptoms, as well as cancer. (Exposed versus unexposed, cancer 10.0% versus 2.08%, bronchitis 17.8% versus 5.8%, and asthma by history 40.5% versus 11.0%) There were significantly more neurophysiologic abnormalities in adults of reaction time, trails A and B, and visual field defects. Conclusions: Adverse health effects were significantly more prevalent in long-term residents near a wood treatment plant than in controls. The results of this study suggest that plant emissions from wood treatment facilities should be reduced.

Keywords: Creosote, Pentachlorophenol; Environmental contamination; Cancer; Population-based studies

1. Introduction

A currently operating wood treatment plant began operations in 1929 in eastern Mississippi; it utilized creosote always and pentachlorophenol from 1951 until 1974. The process involves placing wood in heated, high-pressure chambers, the heat and pressure facilitate entry of the chemical into the wood. The plant is adjacent to several hundred homes and an elementary school. The US Environmental Protection Agency Toxic Release Inventory provided by the company indicates that up to 1 million pounds of chemicals are released from the plant each year.

From their own observations, the residents report daily air pollution emanating from the plant. The neighbors recognize the distinctive odor of creosote. The strongest odor episodes occur in the late evening. The plant regularly raises the creosote temperature to the boiling point to keep the water content below 3%. This practice is called dehydration. The boiling of the creosote may explain the higher level of odor noted by the residents in the evening. The residents report that the levels of creosote odor were sufficient to cause acute headache, nausea, eye irritation, sore throat, and other symptoms intermittently. The long-time residents report stronger odors and symptoms in prior years.

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☆☆The study was conducted in accordance with national and institutional guidelines for the protection of human subjects.

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Throughout the years, large quantities of wood preserving waste (WPW) chemicals were discharged into unlined ditches, which flowed through the neighborhood, emptying into a nearby river. Every few years, heavy rain caused the ditches to overflow, flooding the area and contaminating the yards. Neighborhood children played in the drainage ditches and on the treated wood in the storage yard, sustaining additional dermal, ingestion, and inhalation exposure. Some residents used the treated wood scraps for fuel in their wood-burning stoves. In 1974 a fire in the plant burned for at least 8 h sending large quantities of smoke and soot into the surrounding area. Water to extinguish the fire flowed into the drainage ditches and onto many yards. There was no attempt to clean up the oily residue visible in yards and homes after the fire.

Creosote is a complex mixture, containing over 200 constituents (NIOSH, 1977), which is carcinogenic and toxic. The neighborhood air, water, and soil around the plant have been contaminated with wood preserving chemicals. Environmental testing has been performed by the company, the parties, the state, and the federal government. Many chemical contaminants, including total petroleum hydrocarbons, numerous polycyclic aromatic hydrocarbons (PAHs), chlorinated dioxin and furans, and volatile and semivolatile organic compounds, were identified in the soil near the homes and in the sediment at the bottom of neighborhood drainage ditches. Pentachlorophenol (PCP) is a probable human carcinogen and toxic. Pentachlorophenol is contaminated with polyhalogenated aromatics, including the chlorinated dibenzodioxins (ATSDR, 1998). Pentachlorophenol use was discontinued in 1974 and thus the current exposure to the chlorinated contaminants may be less than it was in earlier years. Recent soil testing has revealed the continued presence of polychlorinated dioxin and furans.

2. Materials and methods

We performed a battery of tests (Table 1) on 214 long-term residents chosen from 1269 nearby residents of the wood treating plant. The final cohort of exposed subjects consisted of 214 African Americans and is referred to as the exposed study group. All exposed subjects were plaintiffs in a lawsuit against the wood treatment plant. We compared the results of the same battery of tests on 139 referents chosen from 479 residents from a similar neighborhood without chemical exposure. All of the subjects analyzed from the selected population were African American. All subjects of the study were fully informed and signed an informed consent to participate in the study.

The exposed subjects were selected from nearby residents of the creosote plant who were plaintiffs or potential plaintiffs in a lawsuit against the wood treatment company. Twelve hundred sixty-nine exposed subjects invited by the law firm completed a proctored questionnaire. Forty to fifty subjects completed the questionnaire at one time in a neighborhood church. All subjects received the same instructions from trained interviewers and completed the questionnaire. An unlikely symptom question was used to evaluate malingering. The list of subjects who completed the questionnaire were sorted by sex and age based upon questionnaire responses. An age- and sex-stratified sample of 240 subjects was selected alphabetically by calling subjects in the order in which they were sorted until each age and sex cell was filled. If there were insufficient responders in a particular cell, a subject from the next-highest age range was called. The selected group of 240 was given appointments for further study. Two hundred twenty-one subjects presented for study. Seven subjects were dropped from the analysis because they were not African America. This group had 199 adults and 15 children under 18. The adults lived near the plant for a mean of 25 years.

The control population was recruited in central Alabama from a neighborhood without any known environmental chemical contamination. Four hundred seventy-nine African American volunteers were recruited by means of announcements from the pulpits of local churches. All volunteers were compensated for their time. They all completed the questionnaire in the same manner as the exposed subjects. One hundred sixty reference subjects were chosen to match the exposed study group using gender and age. If an age-matched subject could not be contacted, one with the next-highest age was chosen. If a gender match could not be contacted, an age match was chosen from the opposite

Table 1
Test battery

(A) Chemistry panel
(i) Chemistry panel
(ii) Complete blood count
(B) Genotoxicity
(i) Serum RNA assay
(C) Urine
(i) Routine urinalysis
(D) Neurophysiological—central
(i) Balance—sway speed and distance
(ii) Reaction time
(iii) Pegboard time
(iv) Color vision—lanthony
(vi) Peripheral fields
(vi) Trials A and B
(E) Neurophysiological—peripheral
(i) Grip strength—jamar dynamometer
(ii) Current perception threshold
(F) Neuropshycological
(i) Culture fair
(ii) Profile of mood states

sex. Health status was not considered in the selection. The selected subjects were given appointments for further study. Of these, 115 adults and 24 children under 18 years of age presented for examination. These subjects are referred to as the control study group.

The questionnaire included 36 review-of-systems questions, which had 11 possible levels of severity. The lowest score was one (1), which corresponds to never having had a problem with that symptom, and the highest score was eleven (11) if the problem was always present. This scale for the review of symptoms allowed a greater range of severity than a simple yes/no or selection of slight, moderate, or severe. The basic questionnaire has been in use for many years on both exposed and unexposed populations (Kilburn and Hanscom, 1998). Questionnaire responses correlate with objective test results. These findings are in preparation for publication. Both exposed and control groups were given an additional questionnaire and examined by an occupational/environmental physician who performed a focused history and physical examination. Both groups were evaluated with a battery of tests (Table 1).

The laboratory studies, chemistry 25 panel, complete blood count, and urinalysis were performed by standard techniques in a commercial clinical laboratory (Pacific Toxicology Laboratories, Woodland Hills, CA). The battery of neurological studies was performed following previously published protocols (Kilburn and Hanscom, 1998). Peg placement was measured using the Lafayette slotted pegboard. Trails making A and B from the Halstead–Reitan Battery were utilized (Reitan, 1958). Visual fields were evaluated using the Humphrey frequency doubling technique-automated analyzer (Johnson and Samuels, 1997). Simple and discriminate visual reaction time speeds were measured using a computerized visual stimulus generator for the letter A (simple) and for the letters A and S (two-choice) (Miller et al., 1989). Color discrimination was measured using the Lanthony desaturated 15 hue test (Lanthony, 1978) and scored by the method of Bowman (1982). Static body balance was measured by head positional tracking, with eyes first open and then closed with feet together and arms folded (Kilburn et al., 1994). Sensory peripheral nerve testing was performed with a Neurometer current perception threshold device (Neurotron, Inc., Baltimore, MD) utilizing three frequencies of low amperage electricity. The current was delivered at 2000, 250, and 5 Hz to the left median and left trigeminal nerve (Bleecker, 1985). Culture Fair was administered to evaluate intelligence (Institute for Personality and Ability Testing, Inc., Champaign, Ill.). The Profile of Mood States (POMS) was used to evaluate the emotional state of the subject (EdiTS, San Diego, CA). The adult POMS was also given to children.

Analysis of covariance was used to test the hypothesis that the mean responses of the control and exposed groups were equal. The variables used as covariates for these analyses include age, weight, height, education level, and gender. The transformations of the response variable and the specific covariates used in each analysis were taken from the literature (Kilburn and Hanscom, 1998). The first step in the analysis of covariance is to test for an interaction between exposure and the covariates. When there is no interaction, the difference between the exposed and control is constant for all values of the covariates. If an interaction exists, the difference between the exposed and control groups is a function of the covariates. For each response variable, the adjusted difference between the exposed and control groups is calculated. The t distribution is used to test the hypothesis that the adjusted difference is equal to 0. Student's t-test was used to test the hypothesis that the mean values of the covariates for the exposed and control groups were equal. The χ^2 test was used to test the hypothesis that the percentage of males in both groups was equal. The χ^2 test was also used to test the hypotheses that the prevalence of abnormalities was equal in both groups. The level of significance for all statistical tests of hypothesis is 0.05. All calculations were performed using STATA 6.0 (College Station, TX).

3. Results

Adult demographic data on the exposed and control groups are presented in Table 2. There were significant differences in the education level of the men between the exposed and control groups and in male and female height between the groups. The duration of smoking, as well as other indices of cigarette smoking, was the same in both groups. The income levels were closely matched in both groups (Table 3).

The answers to all 36 questions in the symptoms review except for the malingering question were significantly different from those of controls. In the

Table 2
Adult demographic data by group

Gender		Exposed	Controls	Significance
Number		199	115	
Gender	M	67	45	NS
	F	132	70	NS
Age (years)	M	43±14	43±17	NS
	F	41±14	46±15	NS
Education (years)	M	11.1±3	13±3	<0.05
	F	12.7±3	12±5	NS
Height (in.)	M	70±2	69±2	<0 05
	F	65±3	64±2	<0.05
Weight (lbs)	M	197±47	201±51	NS
	F	191±58	204±51	NS
Duration of smoking (years)	All	20±12	18±14	NS

Values are means±SD. M, male; F, female.

interest of brevity, only those questions from the symptom review that were statistically different from controls are listed (a complete listing of the questions is available from the authors upon request). Significant differences between exposed and controls occurred in the skin and respiratory irritant questions for both adults and children (Table 4). The severity scores were higher in the exposed group. Skin rash following sun exposure was reported in 29% of the exposed subjects and 5% of controls. As shown in Table 5, the prevalence of chronic bronchitis (17.8% versus 5.8%) and asthma by history (40.5% versus 11.0%) was significantly elevated in the exposed group. There were no significant unadjusted differences between groups in the pulmonary function tests of spirometry, diffusing capacity, or lung volumes. However, when adjusted for the presence of asthma symptoms and lung volume, there was a significant difference in diffusing capacity divided by total lung capacity. These results will be reported elsewhere.

Of the 13 questions reflecting neurological symptoms, all of the results showed significantly higher scores in the exposed compared to the controls. Both adults and children also reported significant differences in their neurological symptoms (Table 6). The control children reported almost entirely "never" for all neurological symptoms except headache.

The neurophysiological studies are reviewed in Table 7. The results indicate that there was a significantly lower performance in the neurophysiological functioning of the exposed subjects in most of the tests performed. The eyes closed, sway speed revealed a significantly increased speed of sway in both children and adults.

Peripheral visual field testing revealed significantly more abnormalities in mean deviation except for the left eye in children (Table 7). The visual field defects showed a patchy distribution of decreased sensitivity.

The peripheral nervous system testing is reviewed in Table 8. The tests of peripheral nerve functions revealed a significantly weaker grip in the exposed. The results of the sensory nerve testing were mixed (Table 8). There were no differences on the sensory testing of the median nerve except at the highest frequency. The exposed required a slightly higher intensity to detect the signal than controls. The exposed subjects had significantly greater sensitivity (i.e., required less stimulus) than controls at all three frequencies in trigeminal nerve testing.

The Culture Fair, a test of general intelligence, revealed no significant difference between the exposed and control subjects. The profile of Mood State showed significantly higher scores for the exposed versus the

Table 3
Income distribution

Annual family income	Exposed (%)	Controls (%)
<$20,000	60	62
$20,000 to $40,000	27	23
>$40,000	9	6
Decline to answer	4	9

Table 5
Respiratory problems by history

Problem	Exposed (%)	Control (%)	*P* value
Chronic bronchitis by history	21.7	4.3	<0.0001
Chronic bronchitis diagnosed by MD	17.8	5.8	<0 0001
Asthma diagnosed by MD	13.1	12	NS
Asthma by history of wheezing	40.5	11.0	<0.0001

Table 4
Mucous membrane and skin irritation severity score[a]

	Exposed	Control	Adjusted difference[b]
Adults			
Eye irritation (frequent blinking and tearing)?	6.9	3.1	−3.8[c]
Skin redness, excessive dryness, or itching?	6.0	2.7	−3 3[c]
Dryness of mouth, nose, or throat?	6.1	3.1	−3 0[c]
Throat irritation?	6.0	2.9	−3.0[c]
Shortness of breath?	5.6	3.1	−2.5[c]
Dry cough?	5.4	3.1	−2.3[c]
Children			
Eye irritation (frequent blinking and tearing)?	4.2	3.4	−0.8
Skin redness, excessive dryness, or itching?	6.6	2.0	−4 5[c]
Dryness of mouth, nose, or throat?	6.6	2.0	−4 5[c]
Throat irritation?	5.2	1.8	−3.4[c]
Shortness of breath?	5.9	2.2	−3.8[c]
Dry cough?	5.6	1.9	−3.6[c]

[a] Corresponds to never having had a problem with that symptom, and the highest score was 11 if the problem was always present.
[b] Difference was adjusted for age and gender.
[c] Difference was significant ($P<0.05$).

Table 6
Neurological symptoms severity score[a]

	Exposed	Control	Adjusted differences[b]
Adults			
Irritability	5.8	2 9	−2.9*
Lightheadness?	5.6	2.8	−2.8*
Extreme fatigue	6.0	3.0	−2.9*
Children			
Irritability	6.1	1.3	−5 2*
Lack of concentration	6.6	1.4	−5 2*
Extreme fatigue	5.7	1.4	−4.4*
Headache?	7.9	4.8	−3.6*
Long-term memory loss?	4.3	1.0	−3.3*
Recent memory loss?	4.3	1.1	−3.1*
Instability of mood?	4.2	1.0	−3.2*

*$P<0.05$.
[a]Corresponds to never having had a problem with that symptom, and the highest score was (11) if the problem was always present
[b]Adjusted for age and gender.

Table 7
Central nervous system neurophysiologic testing

	Exposed	Control	P value
Adults ($n=199$)			
Sway speed (eyes open cm/s)	0 85	0.91	NS
Sway speed (eyes closed cm/s)	1.42	1.28	<0.05[a]
Simple reaction time (ms)	394	340	<0.05
Choice reaction time (ms)	617	598	<0.05[b]
Trails A (s)	67	49	<0.05[c]
Trails B for males (s)	125	130	<0.05[d]
Pegs (s)	91	97	NS
Color score	167	178	NS
Peripheral fields (odmd db)	−3.95	−1.98	<0 05[e]
Peripheral fields (osmd db)	−3.40	−1.75	<0.05[e]
Children ($n=15$)			
Sway speed (eyes open cm/s)	0.99	0.97	NS
Sway speed (eyes closed cm/s)	1.85	1.47	<0.05[b]
Simple reaction time (ms)	372	415	NS
Choice reaction time (ms)	601	574	NS
Trails A (s)	52	41	NS
Trails B (s)	105	102	NS
Pegs (s)	79	79	NS
Color score	188	167	NS
Peripheral fields (odmd)	−4.24	−2.20	<0.05[e]
Peripheral fields (osmd)	−2.97	−1.82	NS

NS, nor significant
[a]Natural logarithm transformed, adjusted for age and height.
[b]Adjusted for age.
[c]Natural logarithm transformed, adjusted for age and education.
[d]Males only. Natural logarithm transformed, adjusted for age and education, controls were significantly slower than exposed subjects.
[e]Adjusted for age and gender.

control populations in both the adults and the children (47.3 ± 38.2 versus 29.9 ± 34.5 for adults and 60 ± 27 versus 36 ± 35 for children).

The laboratory testing showed significant abnormalities in tests of immune system function and hematological variables (Table 9).

There appears to be increased cancer prevalence in the exposed subjects compared to the controls. The total prevalence of reported cancer was higher in the exposed study group. Cancer prevalence was significantly elevated in the total 1269 versus the 479 control subjects who completed the questionnaire (Table 10).

4. Discussion

There are estimated to be 250 wood preserving sites in the United States, which are in need of remediation (ATSDR, 1999). The WPW chemicals from these sites include numerous toxic chemicals. The WPW chemicals are carcinogenic, mutagenic, neurotoxic, immunotoxic, hematotoxic, and hepatotoxic and can cause skin and mucous membrane irritation. To our knowledge this is the first study to evaluate health effects from neighborhood exposure to WPW. The company estimates that 1 million pounds of chemicals are discharged from the site every year. The fugitive emissions and waste discharges from the plant create high levels of naphthalene, benzene, PAHs, and many other chemical contaminants in the neighborhood environment. The near neighbors of this facility have been exposed to large amounts of toxic material. The residents' symptoms of throat and eye irritation, headache, and nausea appear to be the result of overexposure to gaseous creosote. Naphthalene is the largest creosote air constituent in wood treating plants (Randerath et al., 1996). Heikkila and co-workers studied a creosote plant and found naphthalene to constitute $2.2\,mg/m^3$ of the total $3.7\,mg/m^3$ of airborne creosote vapor in the work area. This level of creosote exposure caused neurological and irritant symptoms in the exposed workers. The symptoms experienced by the near neighbors of this study are similar to those reported by the exposed workers of the Heikkila study. Air levels of creosote vapor sufficient to cause symptoms is also accompanied by significant carcinogenic PAH exposure (ACGIH, 1991; Randerath et al., 1996).

Dermal exposure from contaminated soil and water as well as air deposition onto the skin also occurred. A common practice of the young people in the summer was playing in the ditch water. The residents sometimes noticed burning and itching of their skin after contact with ditch water which led some of them to discontinue playing in the ditch water.

The chlorinated dioxins and furans in the soil and ditch sediment in the neighborhood are most likely secondary to earlier contamination by PCP, which is known to contain these contaminants (ACGIH, 1991). Heating of PCP in the wood preserving process and the

Table 8
Peripheral nervous system testing (adults)

		Exposed	Control	P value
Grip strength (ft/lbs)	Males	42	50	<0.05[a]
	Females	28	32	<0.05[a]
Quantitative sensory testing	Left median (2 Hz)	11.9	11.2	<0.05[b]
	Left median (250 Hz)	11.9	12.3	NS
	Left median (5 Hz)	12.0	12.3	NS
	Trigeminal (2000) Hz	10 7	11.8	<0.05[b]
	Trigeminal (250) Hz	10.1	12.6	<0.05[b]
	Trigeminal (5 Hz)	10 6	12.7	<0.05[b]

NS, not significant.
[a]Adjusted for height, weight, and age.
[b]Adjusted for age and gender.

Table 9
Immune system and hematology

	N	Exposed	N	Controls
Immune system				
Lymphocytes (%)	195	31.4*	112	33.6
WBC ($1000 mm^3$)	195	6.36*	112	6.73
Serum globulin (gm%)	195	3 1*	113	3.2
Hematological				
Platelet ($10^5/mm^3$)	194	268*	112	288
Mean corpuscular volume (fl)[a]	195	91.6*	112	88.9
Mean corpuscular hemoglobin (pg)	195	28.5*	112	27.8
Mean corpuscular hemoglobin concentration (g/dL)	195	31.1*	112	31.5

*$P < 0.05$.
[a]fl = femotoliters

Table 10
Cancer prevalence in 1269 exposed subjects

Cancer in questionnaire population	Exposed		Control		P value
	N	Percentage	N	Percentage	
Subjects reporting cancer	126	10.0	10	2.08	<0.05

1974 fire has probably increased the concentration of these compounds in this environment. The long half-life of chlorinated dioxins and furans explains their presence two decades after the cessation of PCP use in the plant. The levels of individual exposure to the "dioxins" are unknown but presumed to have occurred and to have contributed significantly to the health findings.

The OCDDs, HpCDDs, and HxCDDs are the major constituents of the TEQ values. It is likely that the PCP-derived compounds constitute a relatively small part of the overall blood levels expressed as a TEQ value, as the toxic equivalency factors of most of these congeners is relatively low. It is likely that the levels would have been higher while PCP was still in use. We were unable to determine the percentage of PCP contribution to the total TEQ.

The pattern of symptoms in the wood treatment plant neighbors versus the controls is compatible with the conclusion that the higher prevalence of certain health problems is related to wood treatment plant contaminants. The findings of significantly increased cancer prevalence, skin and mucous membrane irritative symptoms, neurological impairment, and altered lymphocyte count and red blood cell indices support the conclusion. These are the expected health effects from the increased levels of the toxicants that are present in this neighborhood.

Carcinogenic chemicals in WPW include the PAHs, which are genotoxic carcinogens and mutagens, while the polyhalogenated aromatic hydrocarbons are tumor promoters and nongenotoxic carcinogens. Randerath et al. (1996) reported that wood preserving waste chemicals present a genotoxic hazard based on their observation of DNA damage in vivo from WPW extracts from wood treatment sites. The authors note that exposure to WPW represents a cancer hazard to humans (ATSDR, 1999). The prevalence of cancer in the study subjects is significantly higher than in the controls. Our finding of higher cancer prevalence in exposed questionnaire subjects provides support to the observation that exposure to WPW increases cancer risk.

The finding that exposed subjects report skin and mucous membrane irritation symptoms more frequently than controls is consistent with the known toxicity of creosote and other WPW. Creosote exposed workers report skin rash symptoms as their most frequent complaint (NIOSH, 1977). Not surprisingly, skin symptoms are among the most common complaints from exposed subjects. Creosote-exposed workers note a high rate of photosensitivity (NIOSH, 1977). The exposed subjects report significantly more skin rash

following sun exposure (i.e., photosensitivity) than controls.

Reports of mucous membrane irritation (Table 4) in adults and children are consistent with the expected toxicity of WPW. Creosote workers report eye irritation, sore throat, cough, and other respiratory symptoms as a consequence of creosote exposure (Heikkila et al., 1987; NIOSH, 1977; Randerath et al., 1996). The significantly increased prevalence of chronic bronchitis and history of wheezing probably reflects chronic irritation from the airborne WPW vapors and particles (Table 5). The lack of a difference in asthma diagnoses by a doctor may reflect the limited access to medical care of both groups.

Pentachlorophenol (Heikkila et al., 1987), polyhalogenated aromatic hydrocarbons (ACGIH, 1991), and some of the constituents of creosote are neurotoxic (NIOSH, 1977). Naphthalene, methylnaphthalene, indene, methyl styrene, toluene, xylene, phenol, benzothiophene, diphenyl, acenaphthene, creosols, and xylenols are the top 12 ingredients in the vapor phase of creosote. Most of these chemicals are known to be neurotoxic. Long-term low-level exposure to neurotoxicants from the wood treatment plant is the most likely explanation for the neurologic symptoms and signs in the exposed subjects.

The symptom of extreme fatigue in both adults and children may be seen as a neurological symptom, but it may also be explained by abnormalities in other organ systems. The hematological changes of significantly reduced platelets and elevated MCV and MCH are consistent with bone marrow dysfunction. Naphthalene has been reported to cause hemolysis. Further studies of the red blood cell kinetics in this cohort are needed.

The finding of significantly lower lymphocytes, white blood cell count, and serum globulin in the wood treatment plant neighbors is consistent with known toxicity from pentachlorophenol (Heikkila et al., 1987) and dioxin (ACGIH, 1991) exposure. These changes are indicative of alterations in the immune system.

Some observers have suggested that plaintiffs in a lawsuit create an inherent selection bias. The basis for this idea is that the subjects who volunteer to be plaintiffs exaggerate their symptoms. A recent study on the question of selection bias reports that plaintiffs are not more likely to enhance their symptoms than is a normal population (Allred and Burg, 1995).

It is our conclusion that living near this wood treating facility has resulted in serious adverse health effects. Additional studies of close neighbors to wood treatment facilities are needed to further delineate the extent of the health problems that are occurring. Such studies are also necessary to define safe levels for these environmental exposures. The subjects of this study are still living in the same conditions. The odor of creosote continues to engulf the neighborhood. WPW liquid waste continues to flow through the drainage ditches in the neighborhood. Our findings indicate that companies need to reduce their emissions and discharges from this type of wood treatment plant.

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